# IOT Technology Used in Energy Harvesting

Deepak J,
Department of Mechanical Engineering, Faculty of Engineering and Technology,
Jain (Deemed-to-be University), Bengaluru, India
Email Id: j.deepak@jainuniversity.ac.in

***ABSTRACT: The conversion of natural energy into the electrical energy is generally known as the energy harvesting. At least one of these energy fields should be available in area of interest to use energy harvesting, and a suitable transducer must be present to convert the energy. Energy harvesting is advantageous because it allows devices to be powered where there are no traditional power sources, reducing the need for battery replacements and runs the end applications. Internet of Things (IoT) edge device, which contain end user equipments that connects to network and communicates with other devices and networks, can be sited in remote areas where important power is inaccessible or the battery replacement is impractical. In this paper, author discussed the energy harvesting techniques, power densities and requirements of power in harvesting. In future, the energy harvesting offers significant advantages to the development and improvement of the IoT.***

***KEYWORDS: Energy, Environment, Harvesting, Internet of Things, Technology.***

## INTRODUCTION

Energy Harvesting (EH) is electronic capture and accumulation of energy from the variability of energy resources that are considered wasted and impracticable for any useful purpose. Energy harvesting, also known as energy scavenging, is the process of extracting remaining energy as the by-product of the natural environmental singularity or an industrial procedure, and is thus classified as the free energy[1]. These remaining energies are frequently unrestricted into environment as squandered potential energy resources.

The widely accepted objective of energy production are all illustrations of mechanical energies from Vibrations, stresses and straining, furnace heat energy, ignition engine as well as several other resources, including bio-solar energies from numerous types of light sources, including light, lightning emission, and sunlight, electromagnetic energies manufactured via transformer wind power, inductor and spinners.[2]. Figure 1 shows the energy harvesting system.

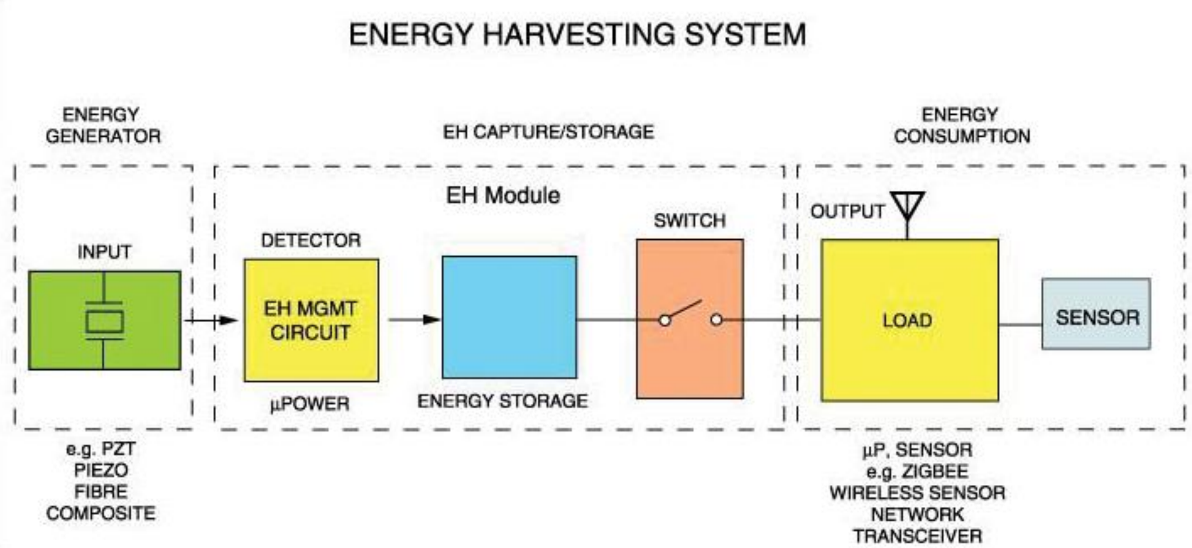


**Figure 1: The Energy Harvesting System Which Shows That How Energy Used In Harvesting System [1].**

Wasted energy resources and sunlight are usually converted into the electrical voltage and current, which can then be stored, harvested and habituated for numerous low voltage of wireless sensor and wearable electronics applications that previously needed alternating current (AC) batteries or power supplies using a variety of well-known devices, material and sensors.

1. *Energy Efficiency, Retention and Management:*

High energy efficiency harvesting electronics are required for proper management of small electrical energy charges such as capturing, accumulating, and storing them. Harvester effectiveness is explained as the captured energy as the direct functions of the energy obtainable for captures detriment the energy consumed by the harvesters electronics to remain active. It's important to keep in mind that harvester circuits must remain active and it will ready to accomplish the energy imprisonment functions whenever harvestable energies becomes available, as well as it will ready to power the applications loads on demand.

The harvester's efficiency is usually low, the alternating energy charges generated by passing cars would have to charged the harvester that almost continuously while in energetic mode to achieved the required outputs power to initiative the load. However, with the well-designed harvesting that is more than 90% efficient, the energy consumed by the harvester electronics will be much less than the sudden energy produced by mechanical vibration and apprehended for storages, allowing for sufficient powering of transmitter even during periods of lower vehicle traffic[1]. For IoT-based embedded systems, technical advancements in energy-efficient have eliminated the need for AC current, making them ideal for remote applications. The advancement of various telemetry technologies and environmental sensors, a growing numbers of morden applications, such as weather data estimations and the real-time parameters monitoring, are gaining traction[3].

The Internet of Things (IoT), also referred to as the Industrial Internet for new technologies that allows global computer networks to communicate with one another. IoT is a critical component of future technology, since many companies are focused on it. The value of the Internet of Things from an industrial standpoint can be understood as devices connected to the global machine network can communicate with one another for customer service, business intelligence applications, inventory systems for suppliers based on their needs, and business analytics. As a result, companies are quickly embracing this technology in order to provide creative technical solutions and to remain competitive.

The (IoT) is a vast infrastructure of the web-enabled smart devices, the small expedients that capture and sumptuous on data collected from the environment using embedded system like processors, communication hardware and sensors. As a result, such devices are made up of power efficient lightweight nodes, storage and scalable that need batteries and power to function. Energy harvesting appears to play a main role to increasing the performance and period of the IoT devices for the reasons mentioned above. IoT is currently in charge of networking technology, which represents a vast numbers of wireless device that can link with internet. Gateways, processors, actuator/sensors, and applications are the four building blocks of IoT systems. They work by analyzing the data obtained by the sensor. Gateways are in charge of moving processed data to the appropriate site. The IoT transport and networking standards are Bluetooth, low power wide area network (LPWAN) and WiF[4].

Sensors collect data from the environment, while actuators/sensors provide the processed data to the energy harvesting. A suitable programme must be used to process the collected data. Traffic control, health care systems, smart buildings and environmental monitoring are some of the most popular IoT applications. The power resources for WSN devices are split into 2 categories: renewable and nonrenewable energy sources. The thermal energy, radiant energy & mechanical energy, are all green energy sources. A batteries and Fuel cells are nonrenewable energy sources. Harvesters of renewable energy sources have the advantages of low volumes, low weight, low environmental impacts and long lifespan. Mechanical energy that has been classified into three categories: steady-states mechanical sources, intermittent mechanical and vibration sources. The vibrations energy can be derived from a vibration source based on its vibration frequency, mass, and amplitude. Air currents and Water flow are the steady states of electric sources[5].

It involves energy derived from human activities like body movement and walking, as well as energy derived from vehicles driving over the energy harvesting system. The replacement of WSN batteries is difficult due to environmental constraints. Aside from that, batteries are very expensive and pollute the atmosphere. As a result, researchers are urged to find for the alternative resource of energy.

Several sources, such as radiation, mechanical motion, light and thermal gradient can be used to extract energy from a sustainable the power supply, and are typically clean and renewable resources of energy, particularly for WSN. Energy constraint connected with WSN creates a bottleneck for the WSN technology. To address this WSN limitation, researchers must look into developing a high-performance harvesting device for the WSN area[6]. The researchers are very enthusiastic about this. An ideal energy harvester must be able to provide continuous energy, which is a difficult task to accomplish. Management and energy storage will help to improve this.

*2. Energy Harvesting:*

Energy recovery (also known as energy collecting or environmental energy) is a process by which power from outside resources is captured and stored, such as in (WSN) and wearable electronics, as well as from external resources such as thermal energy, solar power, wind power, salinity gradient, and cinematic energy. The source of energy for energy harvester is the ambient background while the fuel used to supply a large scales generation costs resources (coal, oil, etc.). For example, a combustion engine has temperature gradients and in urban areas, because of the broadcast of radio and television, the electromagnetic energy in the environment is high[7].

*3. IoT and IoT Edge Devices:*

The IoT is a form of ambient intelligence will focused on the communication of peoples and objects and takes advantage of the adaptive & responsive technological and also help the world to meet the required things. The arrangement of IoT depend system in remote location necessitates long periods of unattended service[8]. Consistent energy management and power supply are the most significant obstacles to achieve this goal. The energy harvesting facilitates on-sites charging of storages units, enabling sensor nodes to work without interruption. Figure 2 shows the six essential building block of the IoT systems.

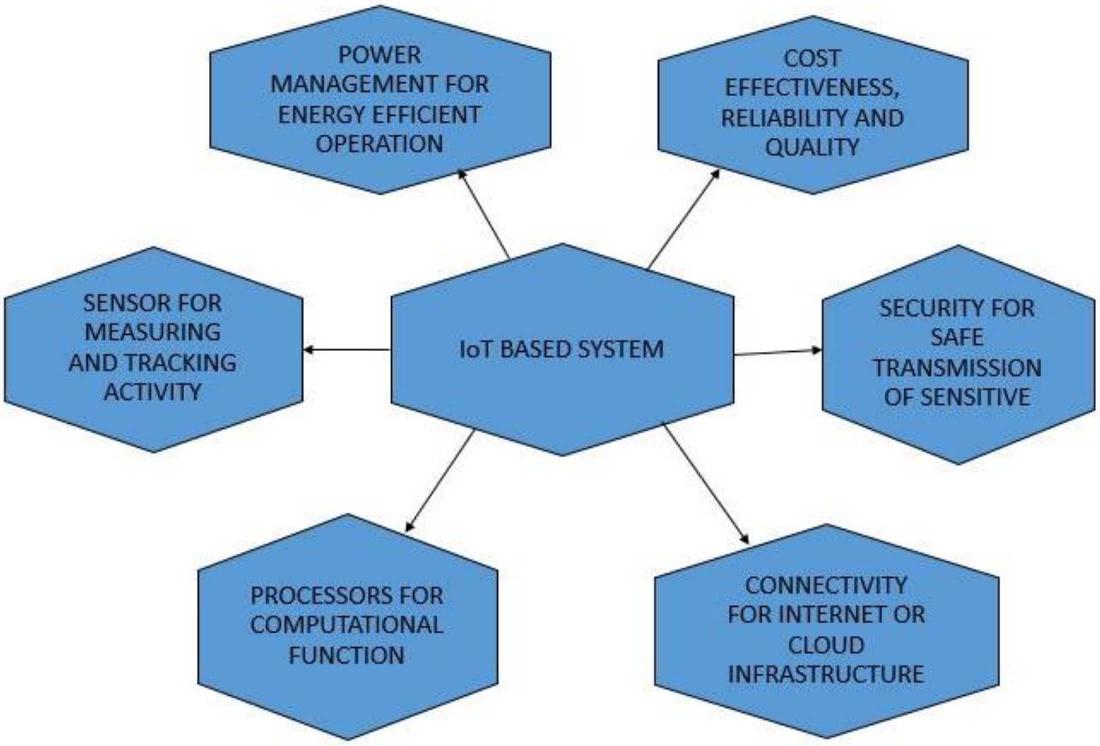


**Figure 2: This Diagram Shows the 6 Essential Building Block of IoT Systems.**

Furthermore, edge devices handle transfer of data between two network boundaries. In a nutshell, service providers use edge devices to serve as network entry and exit points. Reading, filtering, translation, and storage of data, as well as data transmission and routing within network, are among their primary functions. Edge devices are used by IoT-based applications in order to achieve advanced intelligence systems and more computing power. Edge computing refers to the use of logical physical locations and decentralized processes.

The most popular form of edge device is the edge router, which serves as a gateway between different networks. The edge router's primary role is to link a large area networks or the campus networks to the Internet. The Firewalls are a type of edges system that sits on the network's outskirts and filters processed data that during transmission between internally and externally network. Figure 3 shows the edge devices present in IoT system.

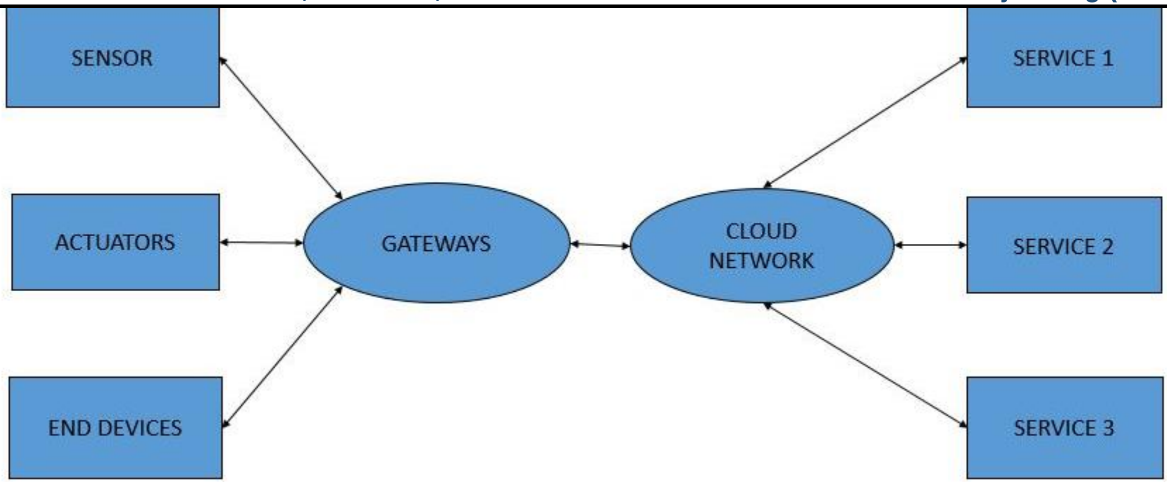


**Figure 3: This Diagram Shows Edge Devices Present In IoT System.**

4. *Solar Energy Harvesting:*

Many photovoltaic material have been utilized in recent year to achieve gradual improvements in systems efficiency. Organic photovoltaic (OPV), crystalline silicon's, dye-sanitized solar cells (DSSC) and other materials are examples of such materials. Copper indium gallium selenide and amorphous silicon are two of the best photovoltaic materials with high performance outdoors and the low performance indoor. Ambient PV cells are used to power autonomous IoT computers, which can supports on-device of the artificial intelligence. The sunlight is changed into electrical energy with the aid of photovoltaic cells. The various harvesters on the market are listed below.

5. *Hydro Watch:*

It is a maximum power monitoring devices and the TelosB platform are used by the Hydro Watch harvester. It's a single sources harvesters with the advantages of do need the battery technology control and it is the quick circuit with 2 NiMH batteries. Although the effectiveness of the produced energy is high, NiMH batteries have a limited lifespan.

6. *Heliomote:*

The harvest also makes use of 2 NiMH batteries, but this time with Mica2 platforms. The amount of the solar energy derived from the harvesters can be simply tracked and monitored. This systems unlike the hydro wristwatch does not utilize the (maximum power point tracking) MPPT. The energy control modules, it keeps tracks the device's energy requirements.

7. *Prometheus:*

Prometheus has the ability to carry a significant amount of energy for an extended period of time. This is why, in order to reduce leakage current, solar energy harvesters use the TelosB platform. The primary buffers are super capacitors, which are linked in series. As a secondary storage battery, a lithium battery is utilized. Prometheus is a double storage solar energy harvester that needs technical power.

8. *Fleck:*

This device is designed to operate only in direct sunlight and powered by two NiMH batteries. The powering of IoT devices is done with a direct converter (DC) so the devices appear to stay on for the longest time possible. Using two super capacitors flecks should be used for battery free systems because they can keep the device alive for 24 hours.

9. *Everlast:*

Everlast is generated by connecting the super capacitor and solar energy nodes with the harvester. It does not need batteries. The use of super capacitors extends the charging and discharging cycles resulting in continuous performance optimization. The super capacitor can be charged effectively using a circuit that includes a buck converters and the switched capacitors. The Everlast has a lifetime of twenty years.

10. *Solar Biscuit:*

These harvesters are quite identical to the first, however in built-in form with an ultra-condenser. The voltage regulator is not required as well as the mega condenser is directly connected to the battery.

*11. Sun Flower:*

There is a super condenser and 4 PIN photodiodes in the structure. Furthermore, a switching controller is needed to charge the condenser and it has infinite lifetime.

*12. AmbiMax:*

This harvester is regarded as a multi-sources energy harvester since it can use wind energy if the solar energy is insufficient or unavailable. There are also secondary and primary energy storage buffers. Controlling the charging of a super capacitors necessitates the use of a hardware circuit[12]. A switching regulators, which is located between the super capacitor and the sources, blocks current flow, resulting in a 12.5 fold increases in speed of the super capacitor charging in the Ambimax harvesters.

*13. Requirement for the Energy Harvesting In IoT:*

The Energy harvesting is the promising solution for powering IoT systems, particularly when it will installed in unapproachable locations where regular battery preservation is impossible. The energy harvesting method extend the device's life cycle and removes the need for fixed charge batteries as a power source. The following are some key factors that emphasize the need for the energy harvesting technologies used IoT applications.

*14. Size Scaling:*

The size and shape of IoT device is no longer a problem due to advancements in integrated circuit technology, which allows multiple features to be combined on the single chip. So, the battery in traditional module design has a one-year life cycle & is a major factors in the complete size and weight of the modules. The energy collection unit size is unique and should not be greater than the previous energy store as an alternative to fixed charge batteries. The energy power harvesting unit's scalability should be optimal for the size of the IoT module.

*15. Cost Factor:*

Because of its mass production, a traditional battery is a cost effective product, resulting in cost sensitive productions of battery powered IoT device. Integrating an energy harvesting techniques into the modules, on the other hand, would raise the cost. Because imbedding an energy harvesting devices on the top of a conventional modules is not a viable solutions and the entire internal designs has to be changed, this cost will include component costs as well as device redevelopment costs. Figure 4 shown the growth of a rechargeable sensors.

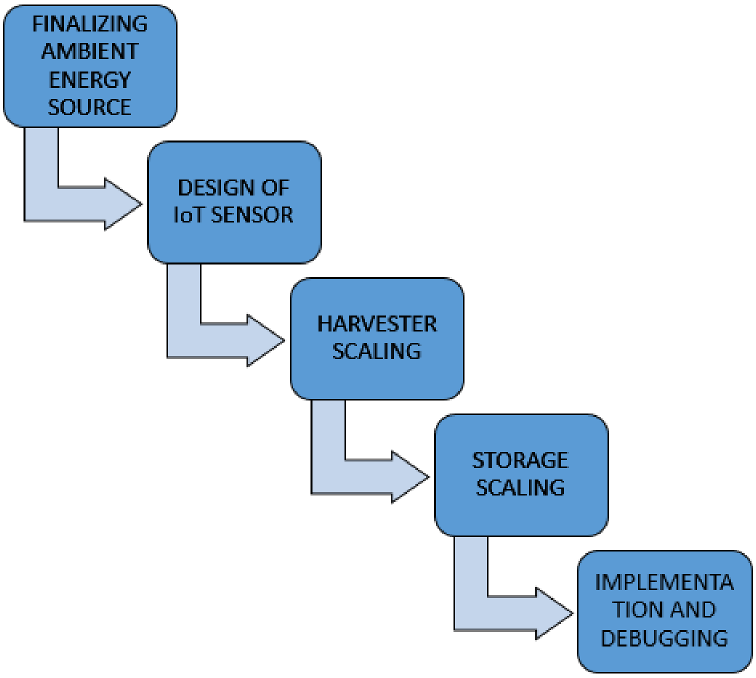


**Figure 4: This Diagram Shows The Growth of a Rechargeable Sensors.**

## DISCUSSION

1. *Harvest Stores in Energy Harvesting Architectures:*

The energy is available in the area of harvesting, this structure harvests it and store it for later use. Since the energy is harvested from the atmosphere, the storages components, such as super capacitors and the rechargeable batteries, must be chosen based on the circumstances. In certain devices, secondary storage may be used in the event of primary storage exhaustion. The solar energy harvester is an e.g. of such a harvesting architectures. A voltage regulator, (MPPT) converter, and photovoltaic cell make up the harvester. One voltage regulator is used to charge the batteries, while the other is used to provide continuous power to the IoT devices.

2. *Energy Harvesting Architecture:*

The harvest use design prevents the use of voltage converters and in the long run, removes energy storage as a result, drawbacks of previous harvest methodology are successfully eliminated, decreasing device costs and potentially improving system performance.

3. *Energy Harvesting:*

Energy harvesting was do not create any issues and embedded developers due to the invention of ultra-low power multipoint control units (MCUs). However, as battery technology failed to keep up with the shrinking geometries of portable devices, energy harvesting began to receive serious consideration. For example, wireless sensor networks would not be possible without ultra-low power MCUs which are aided in part by micro power energy harvesting devices. Solar, thermal, radio frequency (RF), and piezoelectric energy sources are used in the most popular energy harvesting instruments. Solar cells or photovoltaic (PV) cells transform light energy into electricity. Photovoltaic cells have the highest power density and output of all the energy sources. Figure 5 shows the global devices and technologies used for energy harvesting.

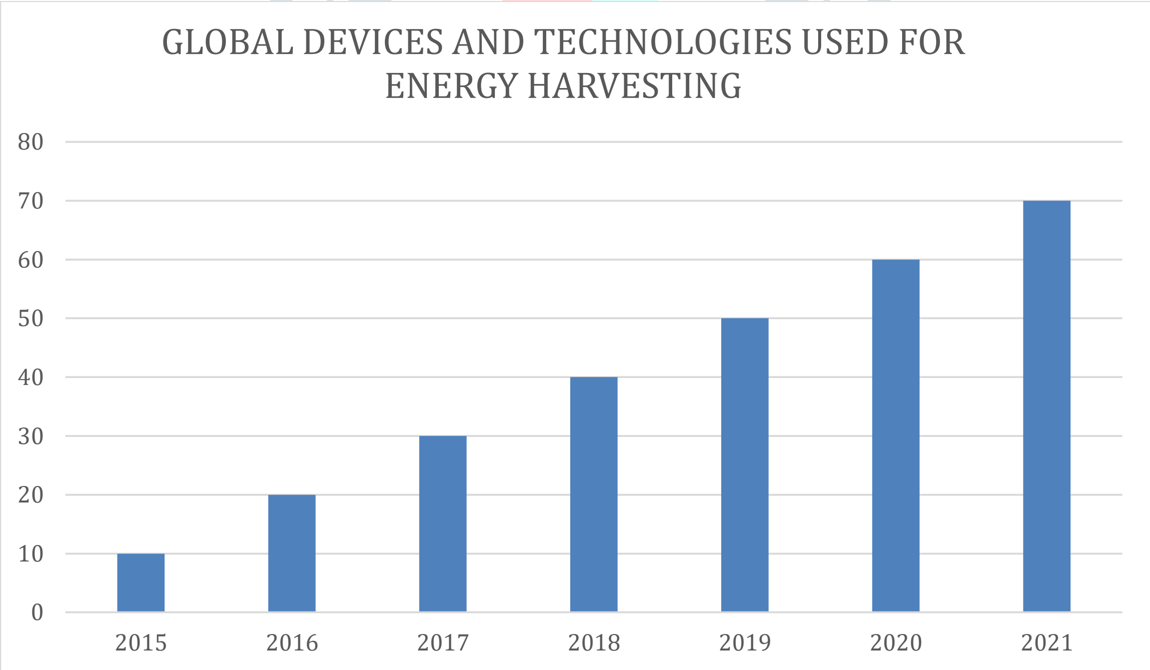


**Figure 5: This Graph Shows The Global Devices and Technologies Used For Energy Harvesting.**

## CONCLUSION

Energy harvesting is critical for improving the reliability and longevity of IoT products. Energy harvesting system have certain drawbacks like: energy sources from which the energy is expected to be collected to being the unavailable harvested energy. To overcomes these constraints some effort have been made and new structures for the harvesting energy that have been created, which are explained in this analysis of the harvest's energy sources. Patient health care systems, infrastructure tracking, military technology, gas sensing, environmental detection and aerospace industry have all benefited from IoT products. In addition, the IoT contain applications in flexible devices and wearable. As the nanofabrication technology progresses, IoT devices will be able to become more portable in the future, resulting in the Internet of Nano-Things (IoNT). These IoNT would necessitate nanoscale energy harvesting and the management, opening up a new area of study for the future.

With several types of the ambient energy sources and consistent energy harvesting methods, different levels of technological sophistication are available. The quantity of power available from various sources varies from the microwatts to mill watts. This range is appropriate for a wide range of IoT devices and applications. In the previous literature paper, several realistic implementations of energy harvesters that provide power to drive IoT devices are surveyed. However, there are a range of technological limitations that prevent energy harvesting technology from being widely implemented around the world. These problems must be resolved in order to fulfil the world's potential demands.

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